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Normal inspiratory muscle strength is restored more rapidly after laparoscopic cholecystectomy

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Respiratory complications after laparotomy cholecystectomy may result from generalised muscle weakness and fatigue, or from reduced respiratory muscle function secondary to an upper abdominal incision. In a prospective study we compared maximal inspiratory effort (Pi_{max}/mmHg) and dominant hand grip strength (kPa) (expressed as a percentage of zero hour value) in patients undergoing open cholecystectomy (OC) ($n=12$), laparoscopic cholecystectomy (LC) ($n=25$) and a control group of patients undergoing lower limb surgery ($n=12$). Of the 12 OC patients, three suffered respiratory complications: two had atelectasis and one a chest infection, compared with no such complications in the other two groups ($P<0.05$). Pi_{max} decreased postoperatively in all groups ($P<0.05$) and had returned to normal by 48 h in the LC and control groups. In contrast, in the OC group Pi_{max} fell from 112.5 ± 17.8 mmHg to as low as 81.3 ± 16.5 mmHg at 72 h and only returned to preoperative levels at 120 h. The hand grip strength fell significantly in all groups at 24 h ($P<0.05$) but normal levels were achieved again by 48 h in all groups, and there was no significant difference in the hand grip strength between the groups over the 5 days. These results suggest that generalised muscle fatigue after surgery is similar after open and laparoscopic cholecystectomy. Open cholecystectomy does, however, cause a more prolonged reduction in respiratory muscle function and this is likely to contribute to the higher incidence of respiratory complications in this group of patients.

Laparoscopic cholecystectomy is a minimal access technique for the removal of the gallbladder. It is associated with minimal trauma to the anterior abdominal wall and may be associated with a reduced surgical insult *(1,2)*; the patient requires a shorter postoperative hospital stay and the result is an earlier return to normal daily activity *(3)*. Respiratory complications frequently follow open cholecystectomy *(4,5)*, but controversy still exists as to whether the upper abdominal incision or the general surgical insult is responsible for such complications. Hand grip strength, a sensitive measure of skeletal muscle strength, and maximal inspiratory muscle strength (Pi_{max}), a measure of both skeletal muscle strength as well as of diaphragmatic muscle function, have been established as parameters for the measurement of the biological response to surgical insult *(6,7)*; Pi_{max} is thus likely to be affected in upper abdominal surgery, although it is also probably affected by diaphragmatic splinting associated with laparoscopic procedures. In a prospective study

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using these parameters, we tested the hypothesis that the minimal abdominal trauma of laparoscopy was associated with better postoperative respiratory muscle strength compared with laparotomy. We also attempted to determine whether general skeletal muscle strength and respiratory muscle strength were affected to the same extent in both laparoscopic and open cholecystectomy, and compared both groups with a group of patients who underwent surgery without laparotomy.

Methods

Over a 9 month period, a total of 49 patients were recruited to the study. Of these, 25 patients underwent laparoscopic cholecystectomy (LC) while 12 patients had an open cholecystectomy (OC). A further 12 patients had neither laparoscopy nor laparotomy. All of these patients underwent elective lower limb orthopaedic surgery.

The patients were not randomised as it was felt that it was unethical to do so; the open cholecystectomy group consisted of patients who had undergone previous upper abdominal surgery. The patients were matched for age, sex and anaesthetic time (Table I). The indication for cholecystectomy was based on symptoms and the ultrasonographic confirmation of gallstones and gallbladder disease. Those in whom laparoscopic cholecystectomy failed and had to be subsequently converted, were taken out of the study. Open cholecystectomy was performed through a standard 5 cm right subcostal incision and laparoscopic cholecystectomy through four ports in the standard positions.

Hand grip strength was measured using a Martin vigorimeter (Ortopedia, West Germany) which consists of a bulb attached to a calibrated pressure gauge which measures hand grip strength in kiloPascals (kPa) *(7,8)*. Maximal inspiratory strength was determined with a Pi_{max} gauge as described previously *(9,10)*. The patients were allowed to familiarise themselves with the equipment and clear instructions including demonstrations were given to the patients by the same person each time. Separate measurements of hand grip strength (kPa) and Pi_{max} (mmHg) were then recorded, the value taken being the average of the three measurements of each parameter. The patients' measurements were initially recorded preoperatively (time = 0) and again postoperatively at approximately the same time in each 24 h interval for at least 3 days.

All patients received 5 mg diazepam orally 1 h preoperatively as premedication. The general anaesthesia used was the same in all patients and intravenous cyclizine was used for immediate postoperative analgesia.

Depending on severity, subsequent pain was treated with pethidine 1 mg/kg every 4 h or diclofenac sodium 50 mg (weight 40–60 kg) or 75 mg (weight >60 kg) intramuscularly. Severity of pain was judged by using the Present Pain Intensity (PPI) scale of the McGill Pain Questionnaire *(11)*. Pain was rated on a scale of 0 to 5; 0 being no pain at all and 5 being excruciating pain. Patients rating their pain at 2 on the scale (discomforting) received paracetamol; those reporting pain of 3 (distressing) received diclofenac sodium and those complaining of 4 (horrible) and 5 (excruciating) received pethidine. Any subsequent postoperative respiratory complications were noted. These were diagnosed on both clinical *(4)* and radiological grounds. Results are expressed as mean ± standard deviation (SD) and statistical analysis was performed using Student's *t* test for paired and unpaired observations. The χ^2 test was used for comparing the incidence of respiratory complications and differences in analgesic requirements. Median pain scores with ranges are tabulated in Table II.

Table I. Mean age, sex and anaesthetic times of the three groups

Group	*Age (years)*	*Anaesthetic time (min)*	*%Females*
Control ($n=12$)	47.4 ± 41.2	92.5 ± 14.0	92.3
LC ($n=25$)	51.3 ± 14.1	116.0 ± 32.4	92.0
OC ($n=12$)	42.4 ± 9.7	107.0 ± 43.1	92.3

Table II. Median pain scores (range) in each group postoperatively (using the PPI scoring of the McGill Pain Questionnaire: scores between 0 and 5)

		Control	*LC*	*OC*
Time	0			
Hours	24	5.0 (—)	4.0 (4–5)	5.0 (—)
	48	4.5 (4–5)	3.0 (0–3)	5.0 (4–5)
	72	3.0 (3–5)	0.0 (0–2)	4.0 (3–5)
	96	3.0 (2–4)	—	2.5 (2–4)
	120	1.0 (0–3)	—	1.0 (1–2)

Results

There was a statistically significant decrease in the Pi_{max} in all three groups within the first 24 h postoperatively ($P<0.05$); the control group from a mean of 123.1 ± 14.3 mmHg to 100.9 ± 9.7 mmHg; the LC group from a mean of 118.8 ± 20.1 mmHg to 98.2 ± 17.4 mmHg and the OC group from a mean of 112.5 ± 17.8 mmHg to 82.5 ± 11.3 mmHg. In the OC group Pi_{max} fell to as low as 81.3 ± 16.5 mmHg at 72 h, and this decrease remained significantly below baseline values ($P<0.05$) for up to 96 h, returning towards baseline (111.7 ± 23.2 mmHg) only at 120 h (Fig. 1). In contrast, the decrease in Pi_{max} in the LC group persisted for only 24 h, returning towards a preoperative value of 113.8 ± 18.2 mmHg by 48 h. This trend was similar in the control group in which the drop in Pi_{max} persisted for only 24 h, returning to a normal value of 127.3 ± 17.1 mmHg by 48 h (Fig. 1). In addition, the Pi_{max} was significantly lower in the OC group compared with the LC group ($P<0.05$) across the 4 days postoperatively.

There was a statistically significant decrease ($P<0.05$)

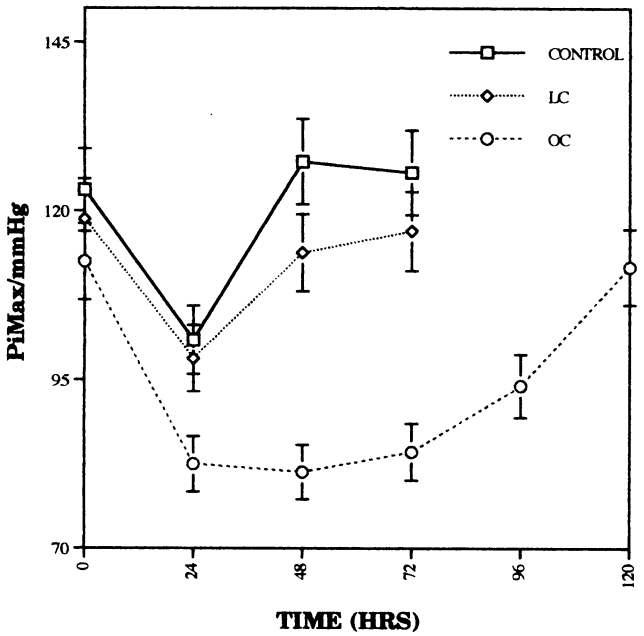

Figure 1. Changes in maximal inspiratory muscle strength (Pi_{max}) in the control, open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) groups. *$P < 0.05$ *vs* time 0 in all three groups, *vs* LC and control from 48 to 96 h postoperatively.

in hand grip strength to an equal extent in all the groups immediately postoperatively; in the control group from a mean preoperative value of 120.2 ± 16.3 kPa to 108.3 ± 17.2 kPa; in the LC group from a mean of 114.0 ± 24.6 kPa to 105.1 ± 11.9 kPa and in the OC group from a mean of 123.8 ± 17.2 kPa to 108.4 ± 13.3 kPa. Normal values were reached by 48 h in all three groups and there were no significant differences between the three groups over the 5 days (Fig. 2).

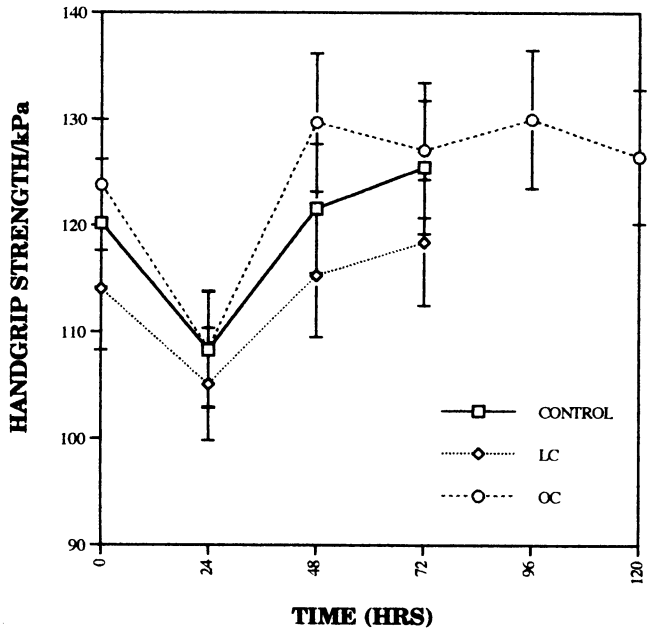

Figure 2. Changes in hand grip strength in the control, open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) groups. *$P < 0.05$ *vs* time 0 in all three groups.

The Present Pain Intensity (PPI) scale of the McGill Pain Questionnaire *(11)* was used to assess the level of pain experienced by the patients in our study. At 24 h the median pain scores were similar in the three groups, but pain diminished rapidly in the LC group compared with the control and OC groups (Table II). These differences in pain scores are reflected in the analgesia requirements. During the first 24 h postoperatively, all patients required opiate analgesia. At 48 h, all the patients in the control and OC groups still required opiate analgesia compared with none in the LC group ($\chi^2 = 13.44$; $P < 0.01$). Only 18 of the 25 LC patients required any analgesia at this stage. At 96 h, 12 control and 12 OC patients were still requiring analgesia, including three who were still on opiates. None of the LC patients were on any analgesia (all the LC patients had been discharged by this time). By the 5th day, all the OC patients were still receiving analgesia and seven of the control patients were also requiring analgesia. These differences in analgesic requirements are reflected in the pain scores (Table II).

Two of the patients in the OC group had atelectasis, with a further one suffering a chest infection, in contrast to no such complications in 25 laparoscopic cholecystectomies ($\chi^2 = 3.86$; $P < 0.05$).

The average time to discharge in the LC group was 2.0 ± 0.91 days postoperatively compared with 7.0 ± 1.21 days in the OC group ($P < 0.01$). The average time to return to work in the LC group was 10.7 ± 2.5 days compared with 22.3 ± 2.7 days in the OC group ($P < 0.01$).

Discussion

The results of this study show a significant decrease in maximal inspiratory muscle strength (Pi_{max}) and dominant hand grip strength at 24 h in patients after general anaesthesia and surgery. However, this effect on Pi_{max} is clearly shown to continue for up to 4 days in the open cholecystectomy group. In contrast, there is rapid improvement in the Pi_{max} after laparoscopic cholecystectomy. Pi_{max} is a measure of both skeletal muscle as well as diaphragmatic muscle function, and indirectly measures respiratory function. Thus, it is clear that open cholecystectomy causes a significant decrease in respiratory muscle function, resulting in a prolonged reduction in Pi_{max} postoperatively.

On the other hand, hand grip strength is a sensitive measure of skeletal muscle function only. There was no significant difference in the dominant hand grip strength noted in any group in this study after the first 24 h. The effect of short-term fasting in normal human subjects has been reported to be insignificant *(6)*. It was found that both hand grip strength and Pi_{max} fell for 24 h in all groups. This could be explained as the general surgical insult and the effect of general anaesthesia being similar in all three groups. It would appear, therefore, that the prolongation of the diminished respiratory muscle strength in the OC group for up to 96 h is due to the

effect of the upper abdominal wall incision and not to the general surgical insult.

Laparoscopic cholecystectomy has lived up to its expectations in that it is associated with fewer respiratory complications postoperatively *(1,2)*, and allows a rapid recovery *(3)*. These points are supported in our study firstly by the lesser analgesic requirements in the LC group compared with the OC group and also by the 25% incidence of chest complications in the OC group in contrast to the larger LC group in which no such complications occurred. The correspondingly prolonged reduction in Pi_{max} in this group suggests that respiratory complications do occur secondary to reduced respiratory muscle function.

Although this study was not randomised, we feel that its value lies in the fact that the patients in the OC and LC groups and also in the control group all act as their own controls. Our findings of respiratory complications after such an upper abdominal procedure are in agreement with other studies *(4,5)*. However, to our knowledge no previous study has used these parameters together to compare and distinguish general and respiratory muscle function after open and laparoscopic cholecystectomy.

In our group of patients, those who underwent laparoscopic cholecystectomy were discharged on average 5 days earlier compared with those undergoing open cholecystectomy. The average time to return to work in the LC group was 10 days compared with twice that in the OC group. These results are comparable to other studies which also report a shorter hospital stay and a faster return to normal daily activity after laparoscopic surgery *(2,3)*.

These results suggest that although the general surgical insult and the effect of general anaesthesia may be similar after laparoscopic and open abdominal surgery, other factors such as wound pain caused by a large abdominal incision impeding mobility and even cultural and economic factors *(3)* may have a more significant bearing on rehabilitation after surgery than the overall actual surgical insult produced by the laparotomy at the time of surgery. The fact that respiratory complications occur more frequently after open cholecystectomy means that total recovery time is also prolonged, as was seen in our patients.

Laparoscopic cholecystectomy has now been established as the treatment of choice for definitive surgery of the diseased gallbladder. However, there are some instances where this minimally invasive procedure is not possible. In the light of our findings, we feel it would be feasible to improve recovery time in patients undergoing open abdominal surgery by taking appropriate measures to improve postoperative respiratory function and reduce wound pain. It has also been shown that postoperative recovery can be hastened by reducing wound pain by infiltration with local anaesthetic agents *(5)*. Also, the use of intensive physiotherapy both preoperatively and postoperatively aimed at restoring respiratory function quickly to lower the rate of pulmonary complications may be of more significant benefit in determining the overall rate of recovery than was previously realised.

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